hundreds of hertz, and no computer is needed to determine the centroid.

The camera is based on a position-sensitive detector (PSD), which is a rectangular photodiode with output contacts at opposite ends. PSDs are usually used in triangulation for measuring small distances. PSDs are manufactured in both one- and two-dimensional versions.

Because it is very difficult to calibrate two-dimensional PSDs accurately, the focal-plane sensors used in this camera are two orthogonally mounted one-dimensional PSDs. The camera also includes a beam splitter and two cylindrical lenses to focus line images of the target onto the PSDs — more specifically, to form a horizontal line image on the vertically oriented PSD and a vertical line image on the horizontally oriented PSD. The outputs from both ends of each PSD are processed by analog circuitry (see figure) to obtain an analog signal proportional to the displacement of the image centroid from the midlength position along the PSD. The direction-measuring error of the readout has been found to be no more than 1/2,700 of the angular width of the field of view.

This work was done by Carl Liebe, Randall Bartman, Jacob Chapsky, Alexander Abramovici, and David Brown of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).
NPO-41466

Polarimetric Imaging Using Two Photoelastic Modulators

The frame rate is the difference between the resonance frequencies of the modulators.

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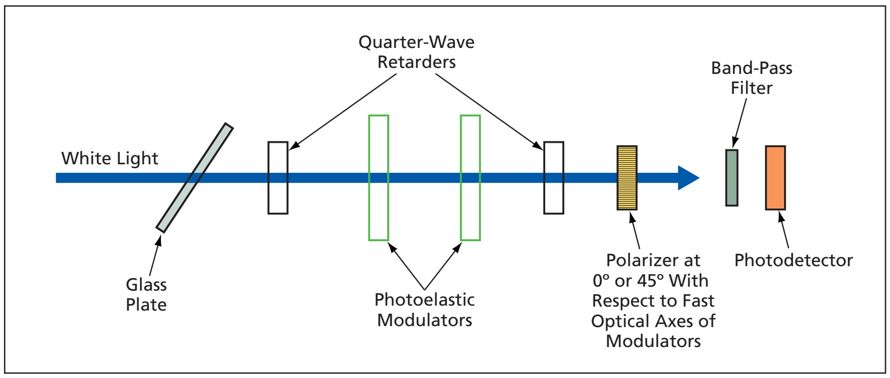
A method of polarimetric imaging, now undergoing development, involves the use of two photoelastic modulators in series, driven at equal amplitude but at different frequencies. The net effect on a beam of light is to cause (1) the direction of its polarization to rotate at the average of two excitation frequencies and (2) the amplitude of its polarization to be modulated at the beat frequency (the difference between the two excitation frequencies). The resulting modulated optical light beam is made to pass through a polarizing filter and is detected at the beat frequency, which can be chosen to equal the frame rate of an electronic camera or the rate of sampling the outputs of photodetectors in an array.



Two Photoelastic Modulators driven at different frequencies were sandwiched between quarter-wave retarders, causing the polarization of the light to rotate at the average frequency at an amplitude that oscillated at the difference frequency.

The method was conceived to satisfy a need to perform highly accurate polarimetric imaging, without cross-talk between polarization channels, at frame rates of the order of tens of hertz. The use of electro-optical modulators is necessitated by a need to obtain accuracy greater than that attainable by use of static polarizing filters over separate fixed detectors. For imaging, photoelastic modulators are preferable to such other electrio-optical modulators as Kerr cells and Pockels cells in that photoelastic modulators operate at lower voltages, have greater angular acceptances, and are easier to use. Prior to the conception of the present method, polarimetric imaging at frame rates of tens of hertz using photoelastic modulators was not possible because the resonance frequencies of photoelastic modulators usually lie in the range from about 20 to about 100 kHz.

It is conventional to characterize the polarimetric state of incident light in terms of the Stokes vector (I, Q, U, V), where I represents the total intensity; Q represents the excess of intensity of light polarized at an angle designated as 0° over that of light polarized at a relative angle of 90°, U represents similarly the excess of intensity at 45° over that 135°, and V represents the excess of intensity of right circular polarization over left circular polarization. It has been shown theoretically that in the present method, there should be no cross-talk between the Q and U channels and that it should be possible to obtain the ratio U/I from two readings of a single photodetector taken when the polarizer is in two orientations that differ by 45°.

The figure schematically depicts a laboratory setup that was used to demonstrate the feasibility of the method. A collimated beam of white light was partially polarized by a glass plate at an oblique angle. The degree of polarization could be changed by rotating the glass plate. The light then passed through a circular-polarization subsystem that included (1) two photoelastic modulators having their fast axes at an angle of 0°, sandwiched between (2) two quarter-wave retarders oriented at angles of 45° and 135°, respectively. The two photoelastic modulators had resonance frequencies of about 42 kHz, differing by a beat frequency of about 9 Hz. The modulated light was then made to pass through a 0° or 45° polarizer on the way to a photodetector. A band-pass filter having a nominal pass wavelength of 672 nm with 20-nm bandwidth was mounted between the polarizer and the photodetector. Results of several experiments at various degrees of linear polarization were found to agree substantially with theoretical predictions.

This work was done by Yu Wang, Thomas Cunningham, David Diner, Edgar Davis, Chao Sun, Bruce Hancock, Gary Gutt, Jason Zan, and Nasrat Raouf of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).
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